

**What is claimed is:**

1           1.    A apparatus for measuring a gate oxide thickness,  
2    which is disposed in a scribe line region, comprising:  
3           a first active area disposed on a substrate, a width of  
4           the first active area is a predetermined width of  
5           at least  $2F$ ;  
6           first to fifth wordlines disposed on the substrate in  
7           a first direction, with a first predetermined space  
8           between each two wordlines, and the first ends of  
9           the first to fifth wordlines are electrically  
10          connected;  
11          first and second bar-shaped trench capacitors disposed  
12          under the second and the fourth wordlines  
13          respectively, with a second predetermined space  
14          between the first and second bar-shaped trench  
15          capacitors, the first and second bar-shaped trench  
16          capacitors are longer than the first active area;  
17          wherein the first space is smaller than the  
18                  second space, and  $F$  is a minimum line width  
19                  of the wordlines; and  
20          first and second gate structures respectively disposed  
21          between the first bar-shaped trench capacitor and  
22          the second wordline and between the second  
23          bar-shaped trench capacitor and the fourth  
24          wordline, each gate structure comprising a gate  
25          conducting layer and a gate oxide layer, wherein  
26          the gate conducting layers are electrically  
27          connected to the wordlines respectively.

1           2.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, wherein the first to fifth wordlines are electrically  
3 connected to a first conducting layer.

1           3.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, wherein the first predetermined space is the minimum  
3 line width  $F$  of each of the wordlines.

1           4.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, wherein the width of the second predetermined space  
3 is  $3F$ .

1           5.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, further comprising a second active area having  
3 a predetermined width of at least  $2F$ , the second active area  
4 disposed on the substrate in a second direction, and the first  
5 active area is connected to the second active area by a second  
6 conducting layer.

1           6.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, wherein the width of the second predetermined space  
3 is  $3F$ .

1           7.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, further comprising a doped layer disposed on the  
3 substrate under a second end of each wordline.

1           8.     The apparatus for measuring a gate oxide thickness  
2 of claim 1, wherein the first direction and the second direction  
3 are approximately perpendicular.

1           9.     An apparatus for measuring a gate oxide thickness,  
2 which is disposed in a scribe line region, comprising:

a first active area disposed on a substrate, a width of the first active area is a predetermined width of at least  $2F$ ;

first to fifth wordlines disposed on the substrate in a first direction, with a minimum linewidth  $F$  between each two wordlines, and first ends of the first to fifth wordlines are electrically connected;

first and second bar-shaped trench capacitors disposed under the second and fourth wordlines respectively, the first and second bar-shaped trench capacitors are longer than the first active area, and with a predetermined space with  $3F$  between the first and second bar-shaped trench capacitors;

first and second gate structures respectively disposed between the first bar-shaped trench capacitor and the second wordline and between the second bar-shaped trench capacitor and the fourth wordline, each gate structure comprising a gate conducting layer and a gate oxide layer, wherein the gate conducting layers are electrically connected to the wordlines respectively, and

a doped layer disposed on the substrate under second ends of the first to fifth wordlines.

10. The apparatus for measuring a gate oxide thickness of claim 9, further comprising a second active area having a predetermined width of at least  $2F$ , the second active area disposed on the substrate in a second direction, and the first active area is connected to the second active area by a second conducting layer.

1           11. The apparatus for measuring a gate oxide thickness  
2 of claim 9, wherein the first to fifth wordlines are electrically  
3 connected to a first conducting layer.

1           12. The apparatus for measuring a gate oxide thickness  
2 of claim 9, wherein the first direction and the second direction  
3 are approximately perpendicular.

1           13. A gate oxide thickness measurement, comprising:  
2 providing a wafer with a scribe line and a memory cell  
3 area;

4 forming a measuring apparatus on the scribe line, and  
5 forming a plurality of memory cells with vertical  
6 transistors in the memory cell area, wherein each  
7 vertical transistor has a gate oxide layer,

8 wherein the measuring apparatus comprises:  
9 a first active area disposed on a substrate,

10 a width of the first active area is a  
11 predetermined width of at least  $2F$ ;

12 first to fifth wordlines disposed on the  
13 substrate in a first direction, with a  
14 minimum line width  $F$  between each two  
15 wordlines, and first ends of the first  
16 to fifth wordlines are electrically  
17 connected;

18 first and second bar-shaped trench capacitors  
19 disposed under the second and fourth  
20 wordlines respectively, the first and  
21 second bar-shaped trench capacitors are  
22 longer than the first active area, and

with a predetermined space of 3F between the first and second bar-shaped trench capacitors;

first and second gate structures respectively disposed between the first bar-shaped trench capacitor and the second wordline and between the second bar-shaped trench capacitor and the fourth wordline, each gate structure comprising a gate conducting layer and a gate oxide layer, wherein the gate conducting layers are electrically connected to the wordlines respectively;

measuring an equivalent capacitance between the first conducting and the first active area;

estimating a thickness of the gate oxide layer of the measuring apparatus according to the equivalent capacitance; and

estimating a thickness of the gate oxide layer of each vertical transistor according to the thickness of the gate oxide layer of the measuring apparatus.

14. The gate oxide thickness measurement of claim 9, wherein the thickness  $d$  of the gate oxide layer of the measuring apparatus is obtained by a formula:  $C = \frac{\epsilon}{d} \times A$ , wherein  $C$  is the equivalent capacitance,  $\epsilon$  is a dielectric constant of the gate oxide layer, and  $A$  is a contact area between the gate oxide layer of the measuring apparatus and the first active area.